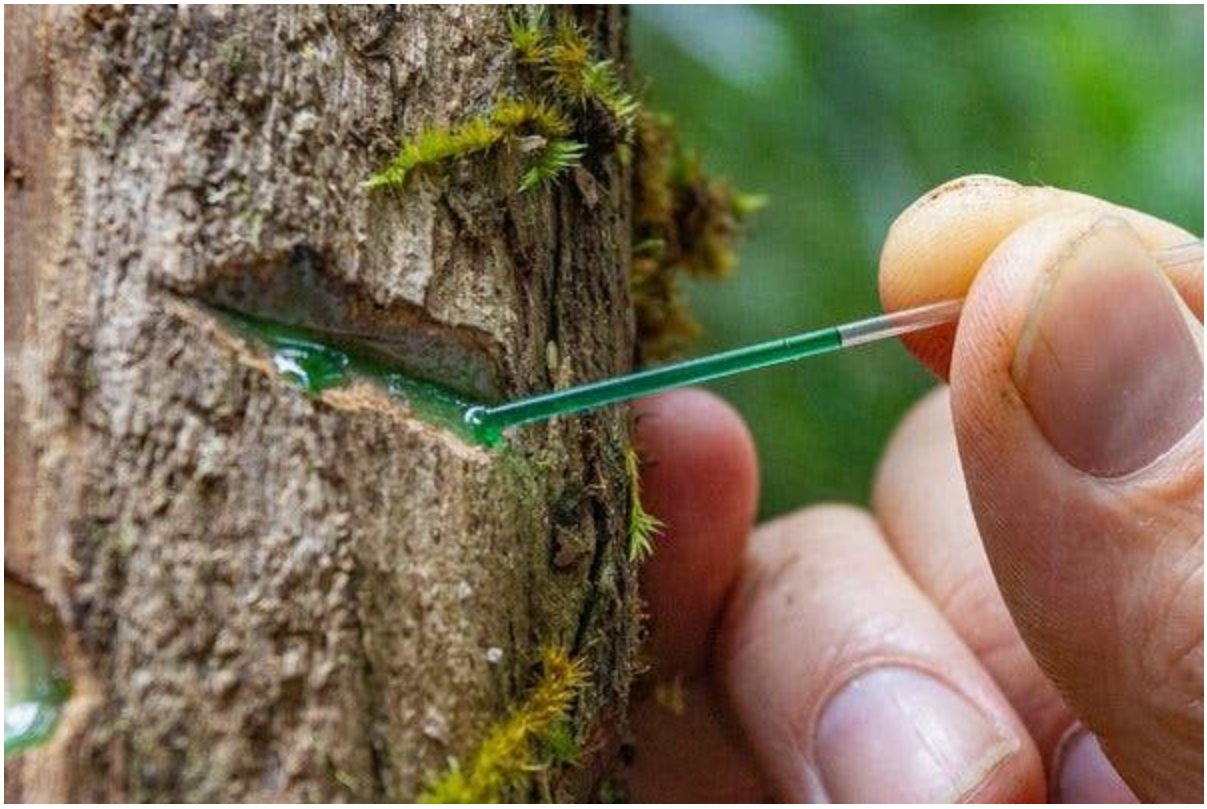
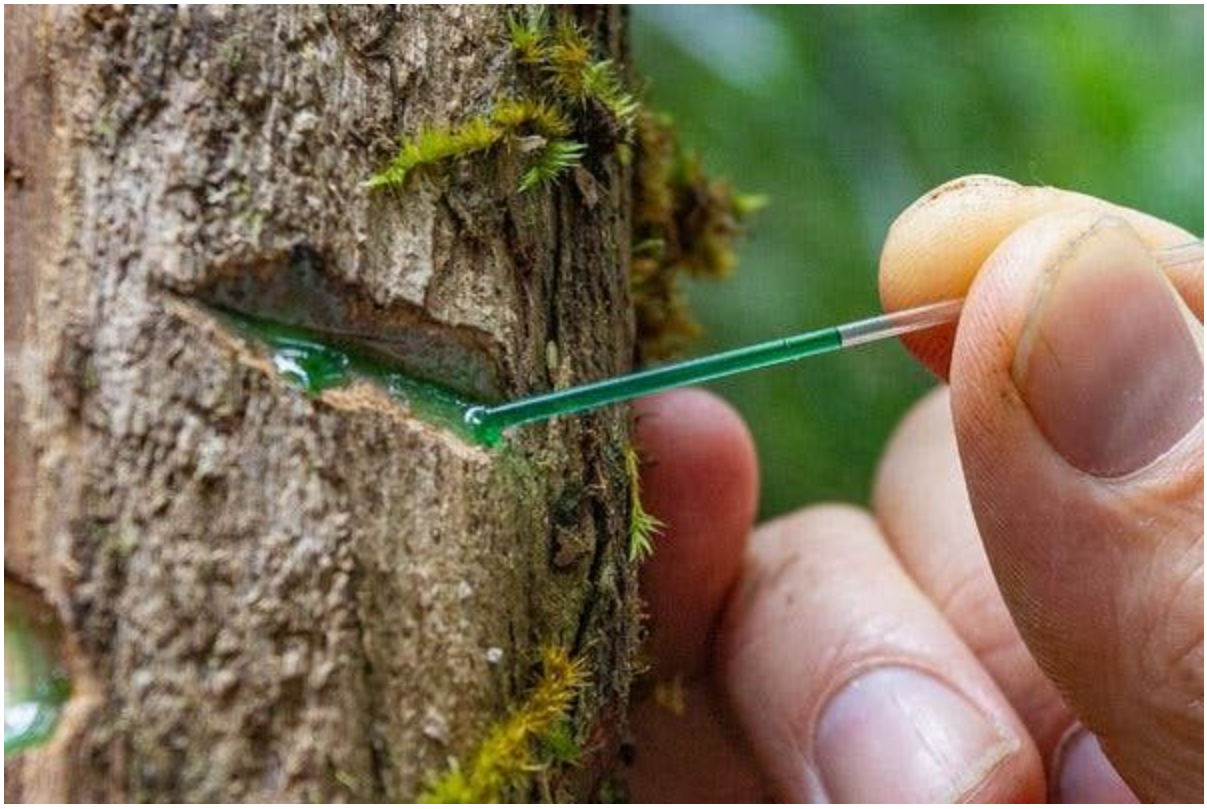
Down on the Farm That Harvests Metal From Plants

Hyper-accumulating plants thrive in metallic soil that kills other vegetation, and botanists are testing the potential of phytomining.





Nickel-rich sap being taken from a tree in Malaysia.Credit...Antony van der Ent

By Ian Morse

- Feb. 26, 2020
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Some of Earth’s plants have fallen in love with metal. With roots that act practically like magnets, these organisms — about 700 are known — flourish in metal-rich soils that make hundreds of thousands of other plant species flee or die.

Slicing open one of these trees or running the leaves of its bush cousin through a peanut press produces a sap that oozes a neon blue-green. This “juice” is actually one-quarter nickel, far more concentrated than the ore feeding the world’s nickel smelters.

The plants not only collect the soil’s minerals into their bodies but seem to hoard them to “ridiculous” levels, said Alan Baker, a visiting botany professor at the University of Melbourne

who has researched the relationship between plants and their soils since the 1970s. This vegetation could be the world's most efficient, solar-powered mineral smelters. What if, as a partial substitute to traditional, energy-intensive and environmentally costly mining and smelting, the world harvested nickel plants?

Dr. Baker and an international team of colleagues has set its sights on convincing the world the idea is more than just a fun thought experiment. On a plot of land rented from a rural village on the Malaysian side of the island of Borneo, the group has proved it at small scale. Every six to 12 months, a farmer shaves off one foot of growth from these nickel-hyper-accumulating plants and either burns or squeezes the metal out. After a short purification, farmers could hold in their hands roughly 500 pounds of nickel citrate, potentially worth thousands of dollars on international markets.

Now, as the team scales up to the world's largest trial at nearly 50 acres, their target audience is industry. In a decade, the researchers hope that a sizable portion of insatiable consumer demand for base metals and rare minerals could be filled by the same kind of farming that produces the world's coconuts and coffee.

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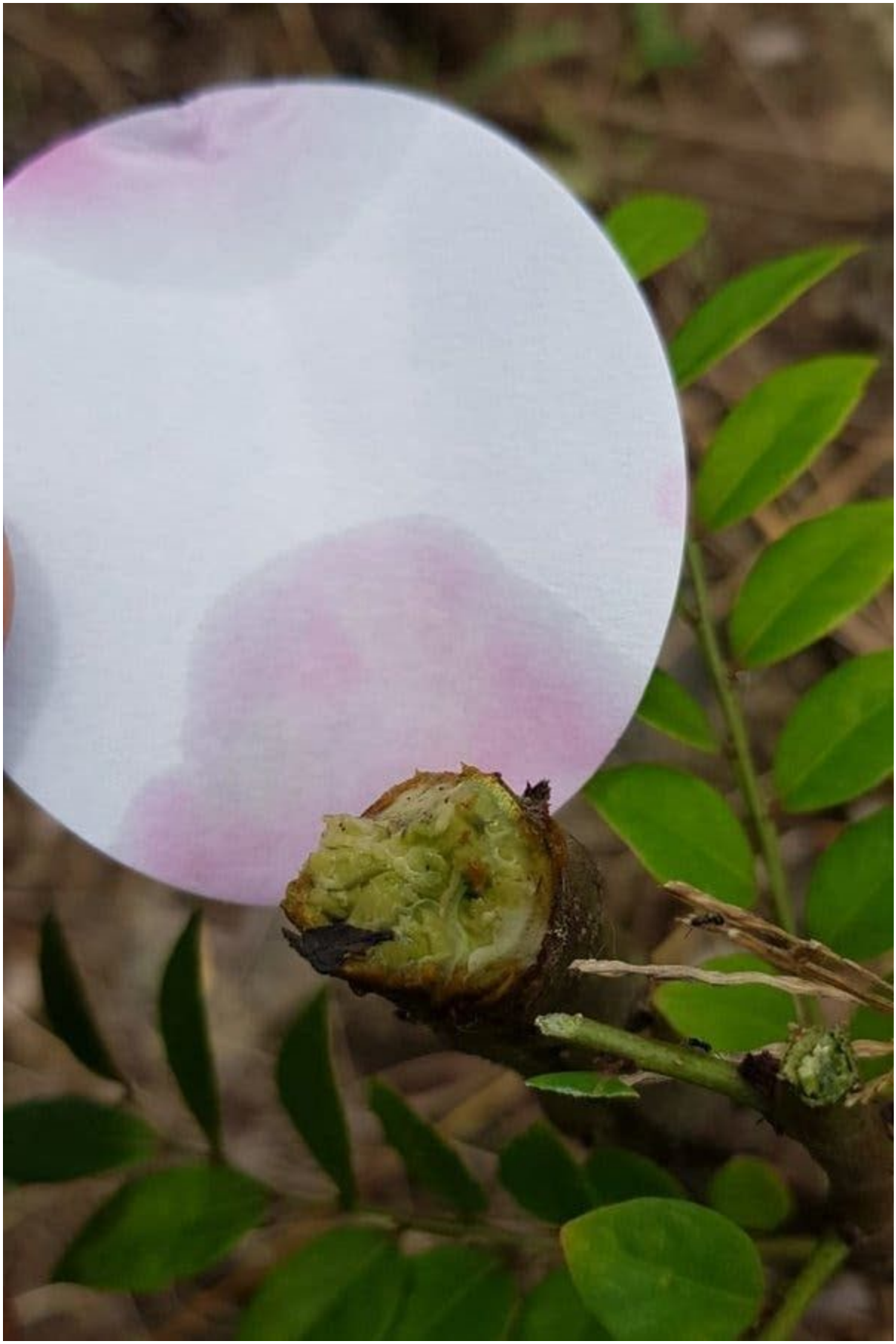

A plant’s sap turned testing paper a reddish color, indicating high nickel content.Credit...Guillaume Echevarria
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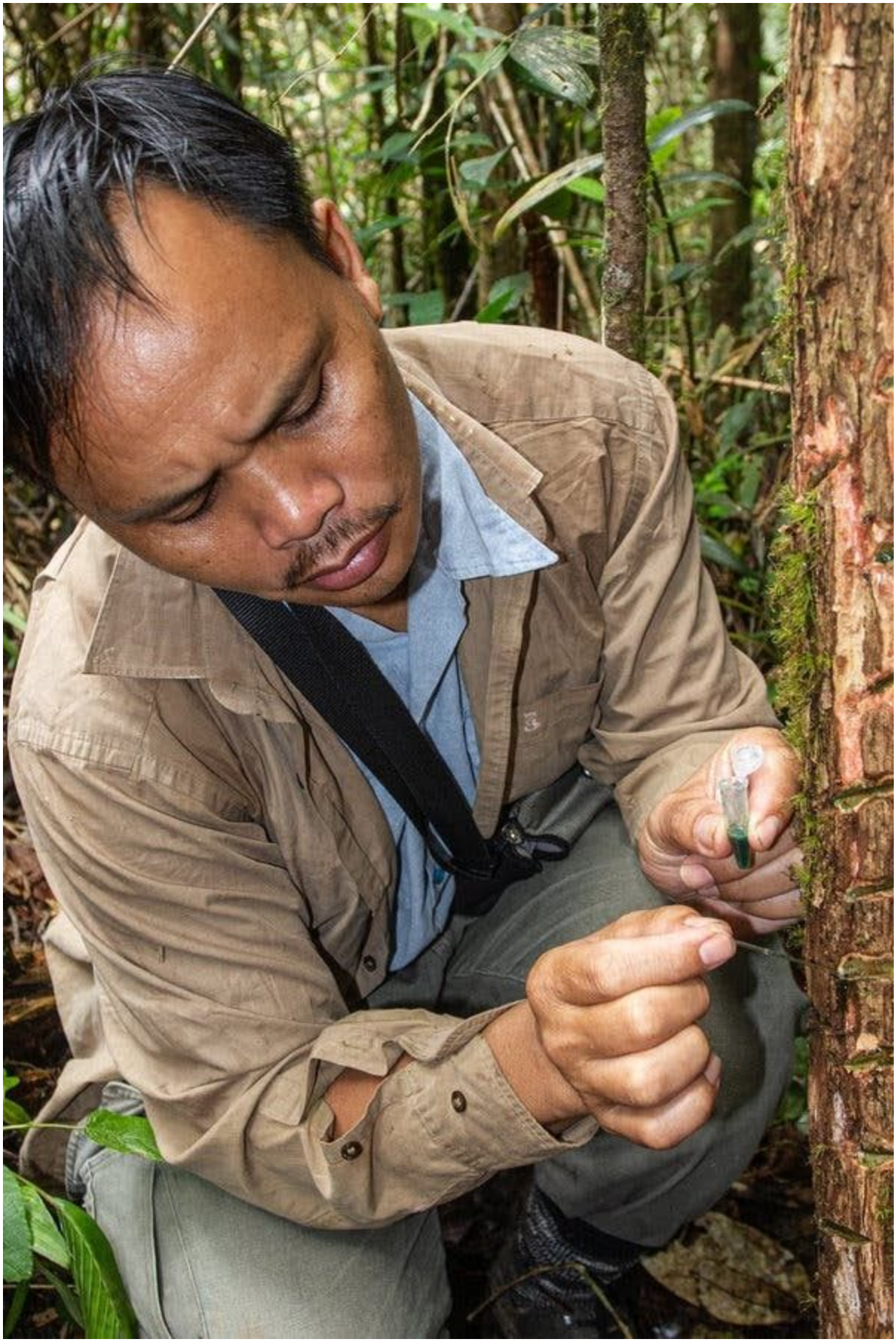


Sukaibin Sumail retrieved nickel sap from a hyperaccumulator tree in Malaysia.Credit...Antony van der Ent

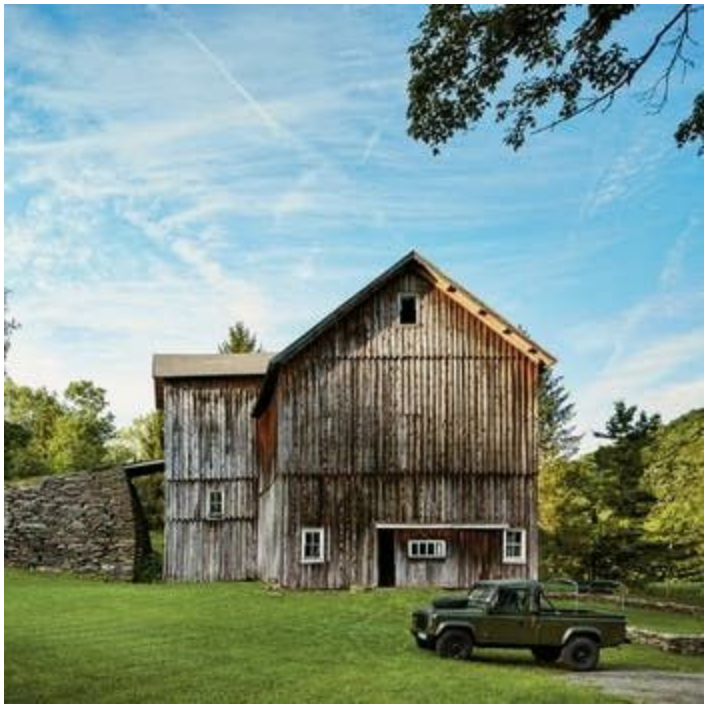
Phytomining, or extracting minerals from hyper-accumulating plants, cannot fully replace traditional mining techniques, Dr. Baker says. But the technology has the additional value of enabling areas with toxic soils to be made productive. Smallholding farmers could grow on metal-rich soils, and mining companies might use these plants to clean up their former mines and waste and even collect some revenue.

“It’s icing on the cake,” Dr. Baker said.

The father of modern mineral smelting, Georgius Agricola, saw this potential 500 years ago. He smelted plants in his free time. If you knew what to look for in a leaf, he wrote in the 16th century, you could deduce which metals lay in the ground below.

Rufus Chaney, an agronomist at the U.S. Department of Agriculture for 47 years, invented the word “phytomining” in 1983 and with Dr. Baker helped begin the first trial in Oregon in 1996. His name is immortalized in one of the nickel-sucking plants used in the Malaysian plot.

Editors’ Picks



A Farmhouse Fantasy Tucked in the Woods of Upstate New York

‘I Only Drink My Coffee Black, and I Cannot Drink It With Sugar’

Now, after decades behind the lock and key of patents, Dr. Baker said, “the brakes are off the system.”

With patents no longer an issue, the scientists hope the technology can benefit small farmers in Malaysia and Indonesia.

“The hope is that we can show it off and have proof of concept and show people how it works, and that it works,” added Antony van der Ent, a plant scientist at the Sustainable Minerals Institute at the University of Queensland in Australia. His dissertation began the Malaysian project.

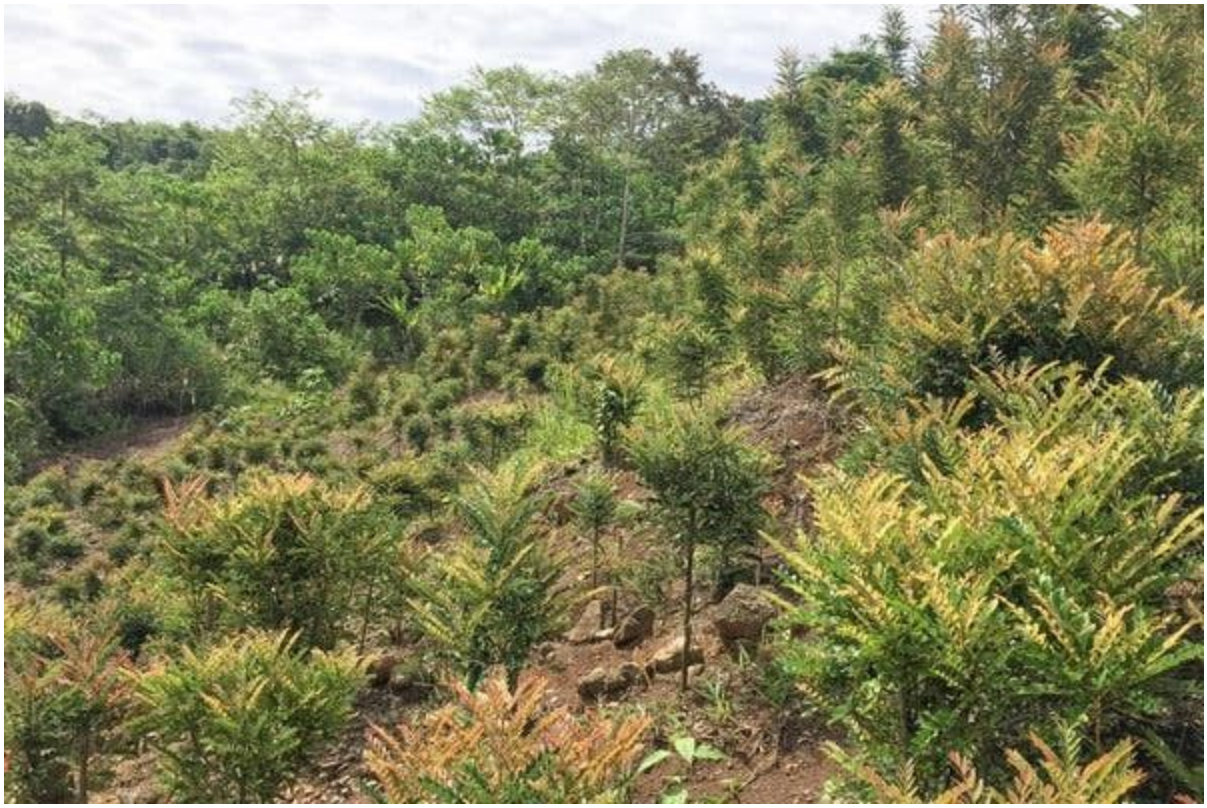
Nickel is a crucial element in stainless steel. Its chemical compounds are increasingly used in batteries for electric vehicles and renewable energies. It is toxic to plants, just as it is to humans in high doses. Where nickel is mined and refined, it destroys land and leaves waste.

In areas where soils are naturally rich in nickel, typically in the tropics and Mediterranean basin, plants have either adapted or died off. In New Caledonia, a New Jersey-size French territory in the South Pacific that has been a major source of nickel, botanists know of at least 65 nickel-loving plants.

Such plants are the most common metal-craving vegetation; others suck up cobalt, zinc and similarly crucial metals. With new electronics spurring surging demand for rare minerals,

companies are exploring as far as outer space and the bottom of the ocean. Far less explored is one of humanity's oldest technologies, the farm.

The language of literature on phytomining, or agromining, hints of a future when plant and machine live together: bio-ore, metal farm, metal crops. "Smelting plants" sounds about as incongruous as carving oxygen.



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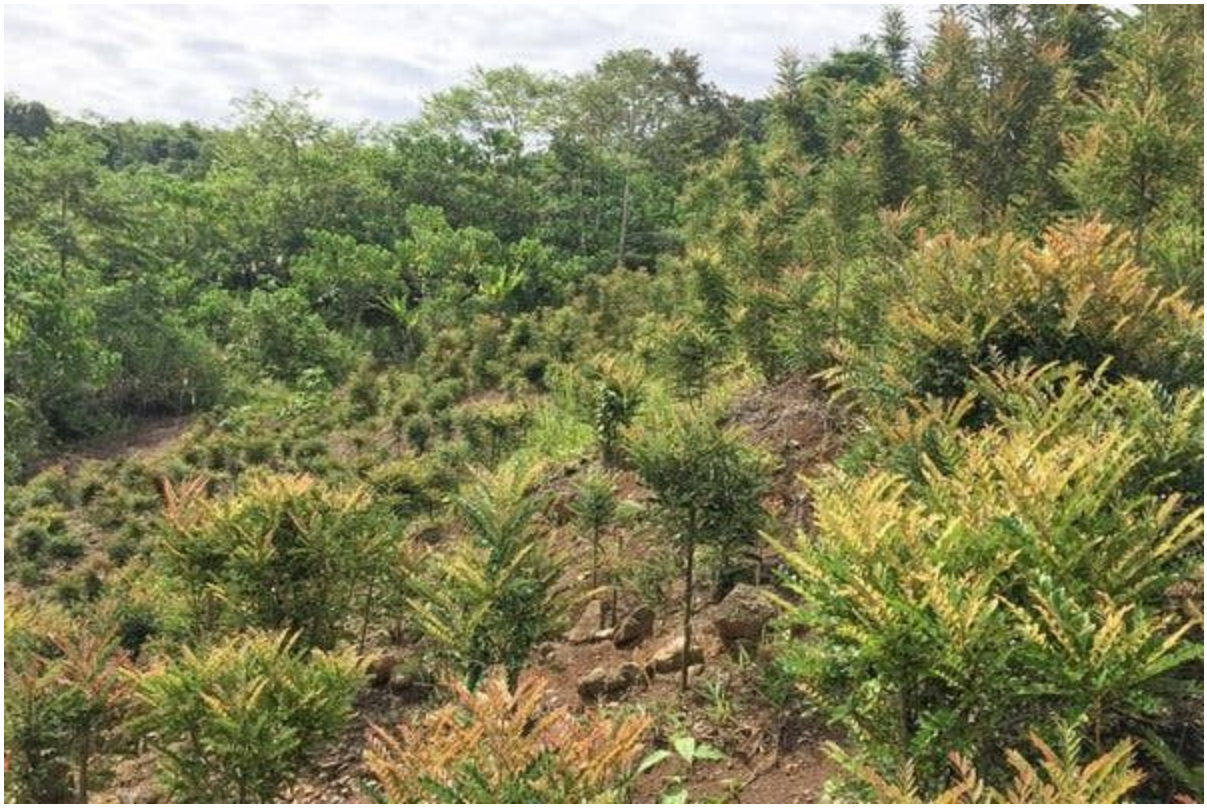

Vegetation on a small plot of land in Sabah, Malaysia, can yield hundreds of pounds of nickel citrate every 6-12 months. The researchers are now testing a larger plot of land.Credit...Antony van der Ent

Proponents of phytomining see the greatest potential in Indonesia and the Philippines, two of the world's biggest nickel ore producers, where hundreds of mines shovel topsoil into smelters. The two countries likely harbor many nickel-hyper-accumulating plants, but research has been scant.

Hyper-accumulators don't just tolerate metals; their roots crave them. To what benefit? The nickel may help the plant fight off pests, or perhaps it enables the plant to more readily take up potassium, a scarce resource, from the soil. Regardless, there has been no need to genetically modify or selectively breed to increase the plants' nickel-philia. Nature's smelters are already as efficient as the extractive industry would want.

They have the potential to remedy the mining industry's biggest problem: abandoned mines, which pollute waterways. A leftover mine, planted with hyper-accumulators, could salvage the remaining metals for additional revenue. That incentive could persuade companies to invest in rehabilitation or mine-waste cleanup.

Currently, the most common way to extract nickel for electronics requires intense energy — often derived from coal and diesel — and creates heaps of acidic waste. A typical smelter costs

hundreds of millions of dollars and requires increasingly scarce ore that is at least 1.2 percent rich with nickel.

In contrast, plants on a small nickel farm could be harvested every six months on land where the nickel concentration is only 0.1 percent. After two decades, the roots would struggle to find enough nickel, but the land would have been sucked dry of its toxic metals, and fertile enough to support more common crops.

That the nickel crop might be so productive and lucrative has led to fears that farmers might push for opening tropical forests for cultivation, foreshadowing another case such as palm oil, a cash crop that has devastated Borneo's native forests. But that isn't a likely outcome, the researchers said. Areas with the most phytomining potential tend to be grassy, and few other plants are likely to grow on land selected for mineral farming.

"We can grow these plants on soils where it's already been deforested," Dr. Baker said. "It's a way of putting back, rather than taking away."